



# Frequency Spectrum Management

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Satellite Direct Readout Conference:

A Decade in Transition

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# Importance of Radio Frequencies for Satellites

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- Vital for transmission from satellite of sensor data and satellite telemetry
- Vital for transmission to satellite of commands to control satellite and maintain health and functionality
- Vital for transmission of processed data
- Requires vigilant management to maintain access to radio spectrum



# Allocation of Radio Frequencies

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- Radio frequencies cover part of the electromagnetic spectrum (9 kHz to 275 GHz is currently allocated by International Telecommunication Union or ITU) is divided into many bands and often allocated to more than one use (or service) in a given band
- 30 different services

# UNITED STATES FREQUENCY ALLOCATIONS

## THE RADIO SPECTRUM

### RADIO SERVICES COLOR LEGEND

AERONAUTICAL MOBILE	INTER-SATELLITE	RADIO ASTRONOMY
AERONAUTICAL MOBILE SATELLITE	LAND MOBILE	RADIO DETERMINATION
AERONAUTICAL RADIOAGNITION	LAND MOBILE SATELLITE	RADIOLOCATION
AMATEUR	MARITIME MOBILE	RADIOLOCATION SATELLITE
AMATEUR SATELLITE	MARITIME MOBILE SATELLITE	RADIOAGNATION
BROADCASTING	MARITIME RADIOAGNITION	RADIOAGNATION SATELLITE
BROADCASTING AIDS	METEOROLOGICAL	SPACE OPERATION
EXPLORATION SATELLITE	METEOROLOGICAL SATELLITE	SPACE RESEARCH
FIXED	MOBILE	STANDARD FREQUENCY AND TIME SIGNAL
FIXED SATELLITE	MOBILE SATELLITE	STANDARD FREQUENCY AND TIME SIGNAL SATELLITE

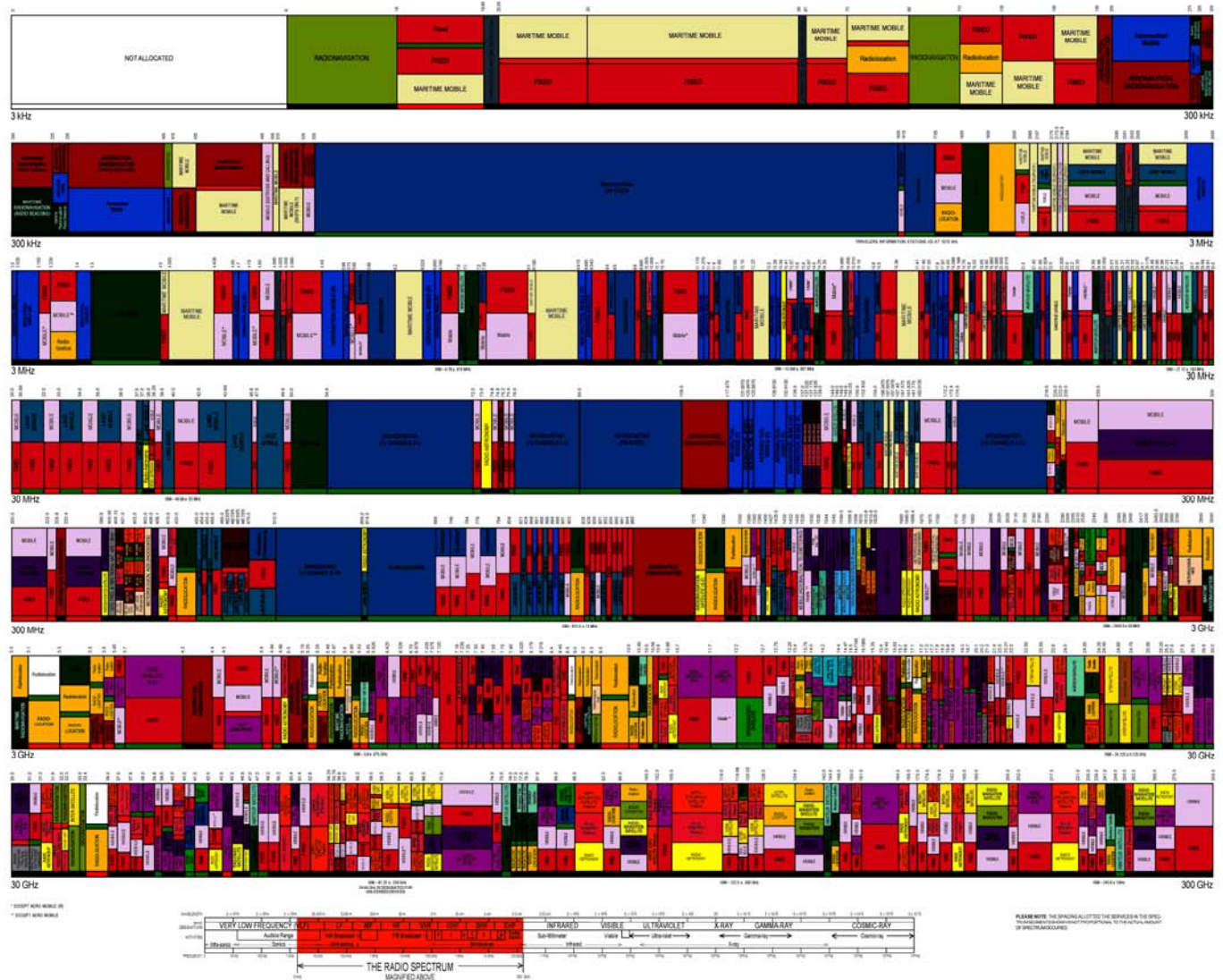
### ACTIVITY CODE

GOVERNMENT EXCLUSIVE	GOVERNMENT/NO-GOVERNMENT SHARED
NON-GOVERNMENT EXCLUSIVE	

### ALLOCATION USAGE DESIGNATION

SERVICE	EXAMPLE	DESCRIPTION
Primary	FIXED	Capitol Campus
Secondary	Mobile	1st Capitol with open class letters

This chart is a public guide and is not intended as the basis of frequency allocations used by the Federal Communications Commission. It is intended to provide a general overview of the radio spectrum and is not intended to be used as a basis for frequency allocations. It is intended to provide a general overview of the radio spectrum and is not intended to be used as a basis for frequency allocations.





# Allocation of Radio Frequencies (cont.)

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- Two types of allocation status, viz. primary and secondary
- Secondary service cannot cause harmful interference to a primary service allocated in same band
- Secondary service must also accept interference from a primary service
- When more than one primary service is allocated to the same band, onus is on new primary user to coordinate with existing primary users



# Basic Radio Frequency Management Principals

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- Management of radio frequencies is controlled both domestically and internationally
- In U.S. the Federal Communications Commission (FCC) oversees all non-Federal Government frequency use (commercial, private, state and local governments)
- The National Telecommunications and Information Administration (NTIA) is responsible for Federal Government spectrum oversight



# Basic Radio Frequency Management Principals (cont.)

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- Internationally, frequency management is under the purview of the International Telecommunication Union (ITU), a United Nations agency headquartered in Geneva, Switzerland
- 189 member nations, over 650 sector members (e.g. private companies)
- Oversees radio regulations and international telecom treaties



# Basic Radio Frequency Management Principals (cont.)

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- Filing of Satellite Systems -- Domestic
  - Through NTIA
  - Four stages of review – conceptual, experimental, developmental, operational
  - Detailed assessment of satellite system by NTIA's System Review Branch
  - Need Stage 4 (operational) NTIA approval before authorization to operate system can be granted
  - Last step in process is to obtain necessary frequency assignments from NTIA's Frequency Assignment Subcommittee





# Basic Radio Frequency Management Principals (cont.)

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- International Filing
  - Geostationary satellites, e.g. GOES, follow strict ITU coordination guidelines
  - Non-geostationary satellites, e.g. NPOESS Preparatory Project (NPP), are required to file with ITU, but only respond to those administrations that request coordination
  - NPP received 10 responses for coordination based on filed frequency bands by 4-month response deadline



# Basic Radio Frequency Management Principals (cont.)

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- International Filing (cont.)
  - Exchange of information (coordination) between NOAA and interested countries to determine if any potential for interference exists
  - If interference potential exists, try to find way to either eliminate or minimize harmful interference so affected space systems can successfully meet mission objectives



# Basic Radio Frequency Management Principals (cont.)

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- International Filing (cont.)
  - Coordination process between countries may last several years
  - Once complete, ITU is notified of the countries with whom coordination occurred, thereby ending international phase



# Proposed NOAA Use of Radio Spectrum, Domestic Filings

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- Stage 4 (Operational) for NOAA N-N' approved by NTIA on 22 July 2004
- Stage 3 (Developmental) for NPOESS approved on 20 April 2004
- Stage 3 for GOES N Series approved on 27 October 2004
- Stage 1 (Conceptual) for GOES R-U approved on 11 April 2002



# Proposed NOAA Use of Radio Spectrum, ITU Filings

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- NOAA N-N' network initial ITU filing (known as NOAA N) submitted for publication in November 2004
- NPOESS network filed with ITU under network known as "NPP". Coordination with 10 countries initiated
- GOES-N Series published by ITU on 2 November 2004 (known as GOES East-2 and GOES West-2)



# NPOESS Coordination Issues

## 1698-1710 MHz

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- Increase in data rates from proposed NPOESS sensors will require new Low Rate Data (LRD) frequency at 1707 MHz
- Current NOAA polar-orbiting metsats co-exist harmoniously with Chinese and Russian metsats
- EUMETSAT's METOP, expected launch in December 2005, must also be considered



# NPOESS Coordination Issues

## 1698-1710 MHz (cont.)

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- September 2004 meeting between NOAA and EUMETSAT discussed interference concerns
  - NPOESS LRD spectrum requirement reduced from 10 to 6 MHz and center frequency moved from 1704 MHz to 1707 MHz to avoid METOP primary downlink at 1701.3 MHz
  - Reduction in NPOESS spectrum will completely eliminate interference between two satellite networks
  - Possible interference would only occur if METOP requires use of backup frequency at 1707 MHz



# NPOESS Coordination Issues

## 7750-7850 MHz

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- X-band, 7750-7850 MHz, proposed as new high rate data (HRD) spacecraft transmission frequency for NPOESS
  - Only recently (1997) allocated for use by non-geostationary metsats
  - METOP and NPP only metsat systems to have filed for band with ITU
  - METOP use will be for transmission of stored data to one large Earth station





# NPOESS Coordination Issues

## 7750-7850 MHz (cont.)

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- No restrictions placed on non-geo metsat use of band. Thus can also use band for continuous broadcast, e.g. NPOESS HRD
- Recommendation by Space Frequency Coordination Group indicates that continuous broadcasts must yield to transmission of stored mission data when co-visibility exists at same ground receiving station
- EUMETSAT's METOP would only use frequency to transmit stored mission data to Svalbard, Norway



# NPOESS Coordination Issues

## 7750-7850 MHz (cont.)

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- Initial coordination meeting in September 2004 with EUMETSAT discussed possible alternatives on reduction/avoidance of interference
- Possible solutions include adjustment of satellite orbits to minimize co-visibility (i.e. interference) of 2 networks at Svalbard, use reverse polarization, reduce NPOESS HRD emissions, turn off HRD signal modulator
- Coordination continuing



# GOES-R Coordination Issues

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- Next generation of NOAA geo metsats (GOES R-U) will have enhanced sensors producing much higher data rates than current GOES
- Must look to higher radio frequencies to meet increased bandwidth requirements
- All allocations are shared with other satellites services, coordination required



# GOES-R Coordination Issues

## X-band Downlink

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- 8025-8400 MHz Earth Exploration Satellite (EES) allocation (Metsats are subset of EES)
  - Many existing polar-orbiting EES networks
  - Deep space allocation at 8400-8450 MHz must be protected from interference
  - Bilateral coordination between various countries may be necessary resulting from future ITU publication of GOES R-U network
  - Requires coordination with DoD for at GOES 135W
  - From initial analyses, appears that GOES-R should be able to operate without significant interference



# GOES-R Coordination Issues

## X-band Downlink (cont.)

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- 7450-7550 MHz Metsat downlink, Fixed Satellite uplink
  - Coordination with DoD indicates possible GOES-R use of band at 135W
  - GOES-R data rates may require bandwidth in excess of 100 MHz allocation
  - Requires further study of expected data rates and of modulation, encoding and compression techniques



# GOES-R Coordination Issues

## X-band Uplink

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- 8175-8215 MHz
  - Technically difficult to have both downlinks (8025-8175 MHz and 8215-8400 MHz) and uplink (8175-8215 MHz) on same spacecraft
  - Requires coordination with DoD for GOES location at 135W
  - If technical solution not feasible, will need to look elsewhere for necessary spectrum

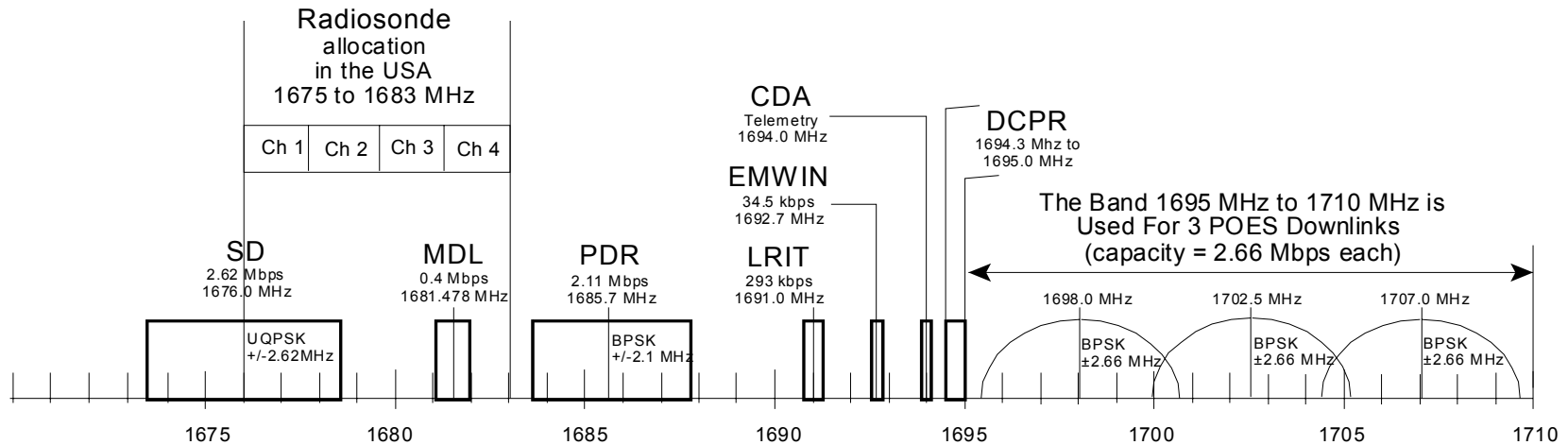


# GOES-R Proposed L-band Spectrum Realignment

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- Need to provide as much processed (re-broadcast) data from advanced instruments as possible
- 1683-1698 MHz is only available spectrum to provide service without significant limitations
- Also need to accommodate auxiliary services (LRIT, EMWIN, DCP and telemetry) in 15 MHz band

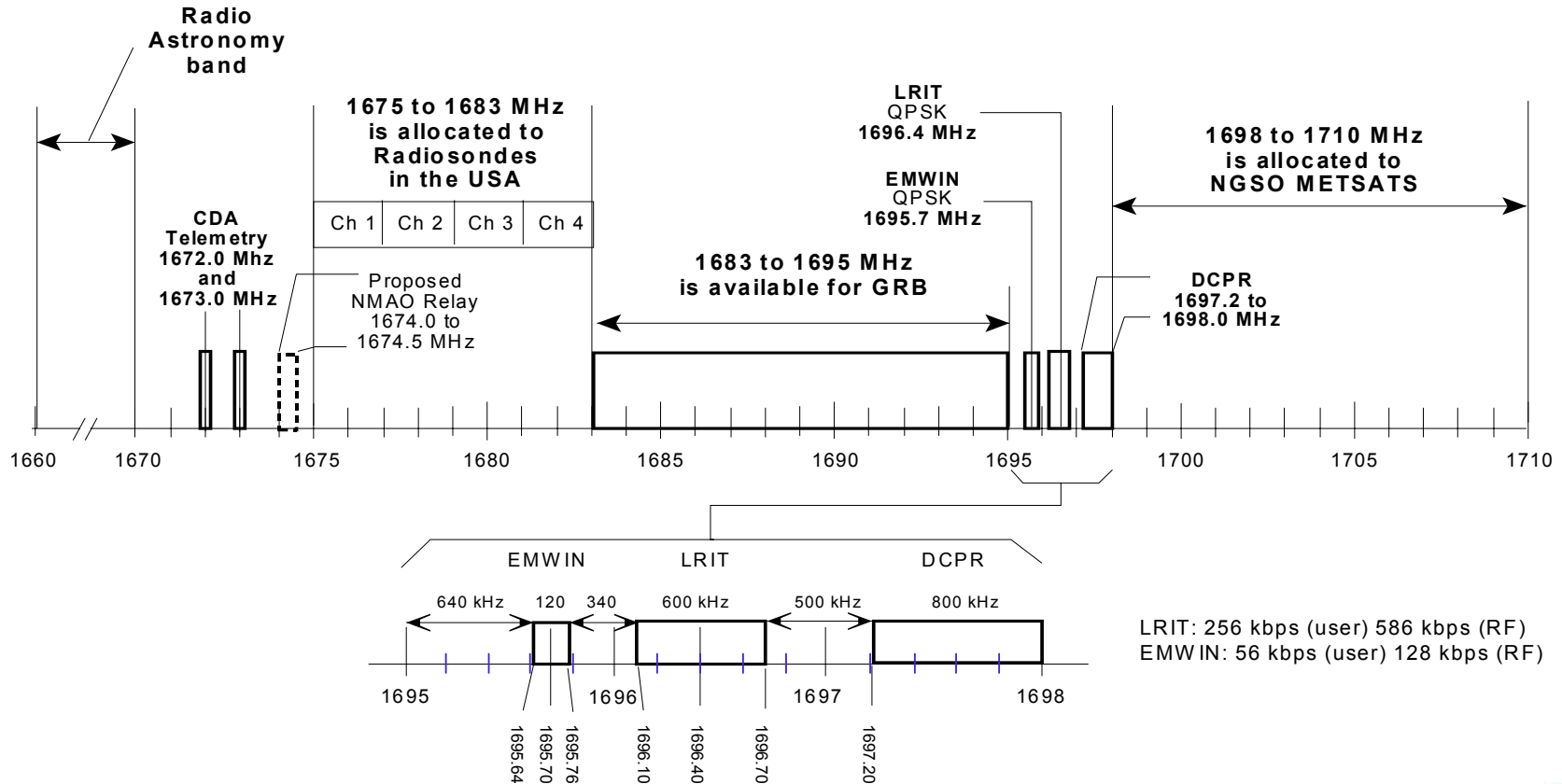
# L-band Usage for GOES N-P



LRIT: 128 kbps (user) 293 kbps (RF)  
EMWIN: 19.2 kbps (user) 34.5 kbps (RF)



# GOES R L-band Downlinks: One Proposed Configuration



LRIT: 256 kbps (user) 586 kbps (RF)  
EMWIN: 56 kbps (user) 128 kbps (RF)



# CITEL

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- Inter-American Telecommunication Commission (CITEL)
- Part of Organization of American States (OAS)
- Website: <http://www.citel.oas.org/>
- 21 CITEL members
- PCC-III (Permanent Consultative Committee III) concerned with radio frequencies
- Standards coordination, planning and full and efficient use of radio spectrum and satellite orbits
- Request support of metsat radio frequencies through CITEL representative



# Summary

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- Process exists to coordinate use of radio spectrum through ITU and domestic frequency regulations
- Such coordination can lead to harmonious use of same frequency band by several satellite systems
- Use of frequencies on NPOESS for LRD and HRD will require international coordination with other metsat systems
- GOES-R spectrum needs still evolving, but initial investigations indicate possible frequencies to meet anticipated spectrum requirements